End-use Load Profiles for the U.S. Building Stock

Technical Advisory Group Meeting #6
March 5, 2020

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Andrew Parker, NREL
Elaina Present, NREL

Logistics

- Welcome back!

- Because of the large number of participants on the phone, everyone is in listen-only mode during presentations.

- Please use the chat box to send us clarifying questions during presentations. We will unmute lines after each topic for open dialogue.

- Slides will be available after the webinar on the project website https://www.nrel.gov/buildings/end-use-load-profiles.html

Agenda

- April Technical Advisory Group Meeting Update
- Progress updates and discussion
  - Calibration data procurement
  - Update on residential end-use transferability study
- Next Steps

April Technical Advisory Group Meeting Update

April Technical Advisory Group Meeting Update: Draft Agenda

- In-person meeting is April 13-14 in Golden, CO at NREL.

- If you are unable to join us in person, we will have a phone option with a webinar of the presentations, and breakout group call-in options.

- Draft agenda
  - Monday, April 13
    - 11–Noon: Arrive and visitor check-in/badges, coffee/tea
    - Noon–1pm: Lunch, intro presentations
    - 1–4pm: Large group and breakout sessions
    - 4–5pm: Tour of Energy Systems Integration Facility https://www.nrel.gov/esif/
    - 6pm: No-host dinner at Edgewater Public Market
  - Tuesday, April 14
    - 8–9am: Breakfast, coffee/tea
    - 9–Noon: Large group and breakout sessions
    - Noon–1pm: Wrap up and box lunches

April Technical Advisory Group Meeting Update: Draft Topics

- We are working on finalizing the content, but topics may include:
  - Preliminary results of region 1 residential model calibration
  - Plans for region 2 residential and region 1 commercial model calibration
  - Updates on calibration datasets
  - Updates on residential transferability study
  - Details of uncertainty quantification approach
  - Stochastic occupancy modeling approaches
  - Final output products & formats (e.g., what people want, what is feasible, tradeoffs)
- Interest in learning about an NREL project developing heat and electric load profiles for the industrial sector?

# April Technical Advisory Group Meeting Update: Logistics

- If you are a non-US citizen attending the meeting in-person, please contact Barbara.VanDyke@nrel.gov IMMEDIATELY to complete the paperwork

- Attendance and Food I will re-confirm who will attend in person and participate via phone NEXT week. I'll send a VERY short SurveyMonkey. Please respond promptly to this because it will help us plan for food and create our break-out groups (on the phone and in person)

- Getting here and away
  - The meeting will be held at the National Renewable Energy Lab in Golden. To get to NREL from the Denver airport, there is information here, and there is also public transportation via the light rail:
    - Take the light rail from the airport to downtown Union Station (A Line)
    - Transfer to W line from Union Station to Federal Center Park-n-Ride
    - NREL Shuttle picks up from Federal Center Park-n-Ride

- Accommodations
  - Information about NREL is located here. Hotel recommendations are available here. We have a hold on a block of rooms at the Marriott West until March 22 for $119.00 per night. You will need to call Marriott Reservations at 1-800-228-9290 or 303-279-9100 to make reservations and identify yourself as part of the National Renewable Energy Laboratory block. If you stay at the Marriott, there are shuttles that run from the hotel to the lab or it is a short walk. If you have any questions, please contact me or Barbara Van Dyke.

Discussion

We are going to unmute all of the phone lines, so please mute yourself if you are not speaking.

Update on calibration data – AMI

Completed NDAs for AMI & In-Hand AMI Data
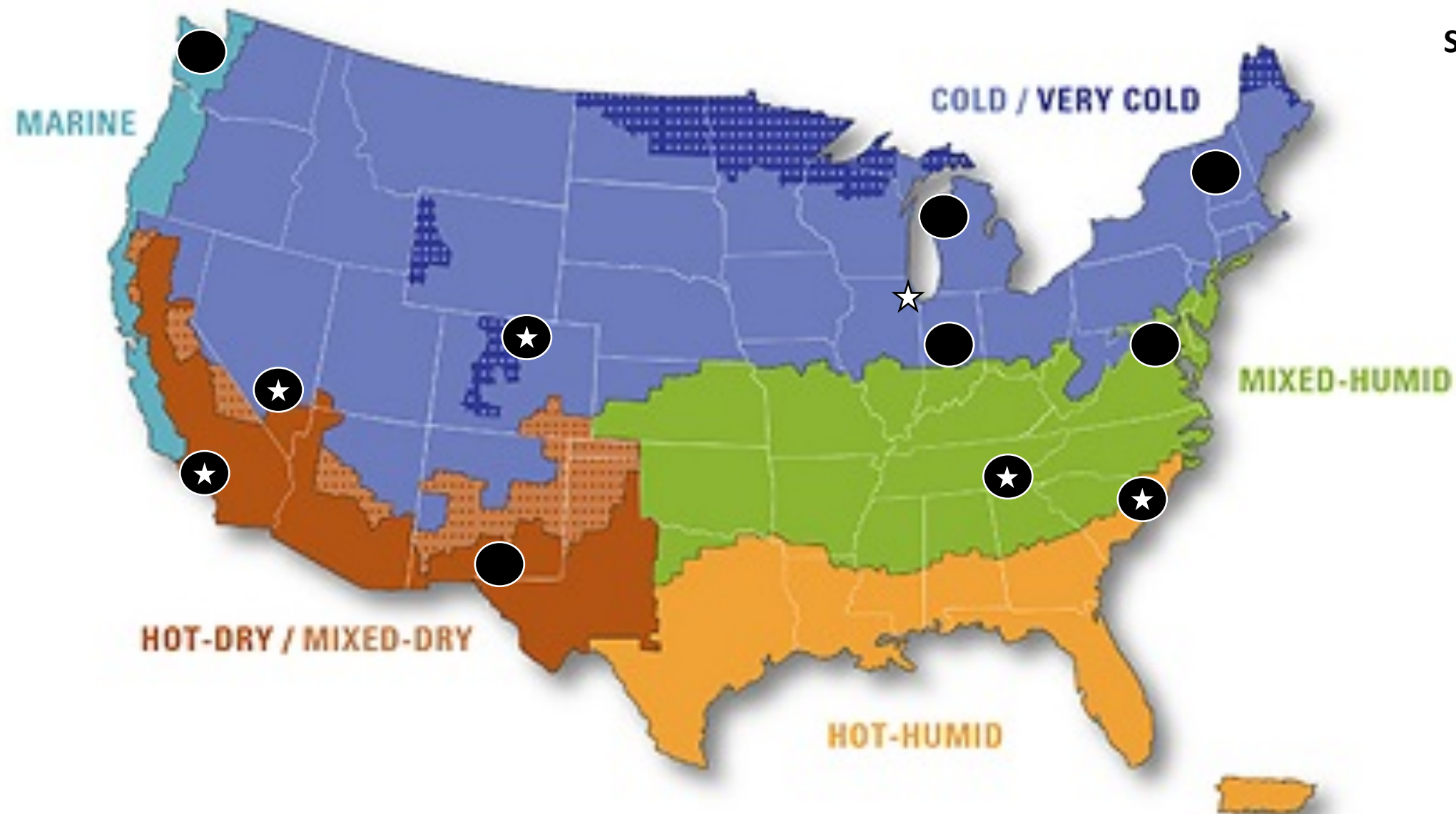
Substantial Utility AMI Datasets
Current status

☆ Data in hand (6)

● NDA completed (11)

Four additional NDAs in progress.

Many more conversations underway

Update on calibration data procurement – Commercial sector end-use data

Market Research for Funding Prioritization

Identify data types to request
- Done

Identify companies to reach out to
- Done

Reach out to companies by email
- Done

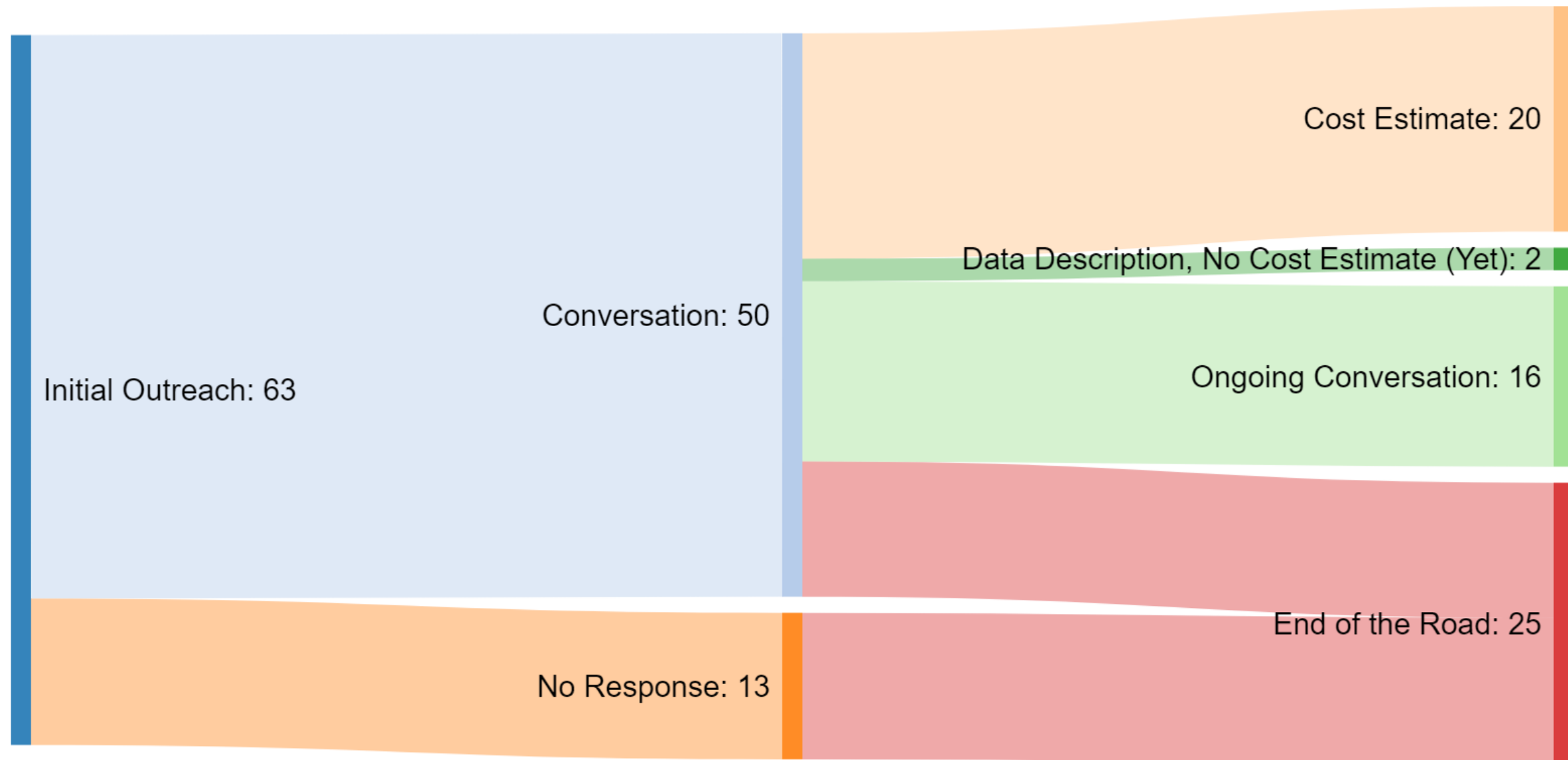**Hold phone conversations with each company**
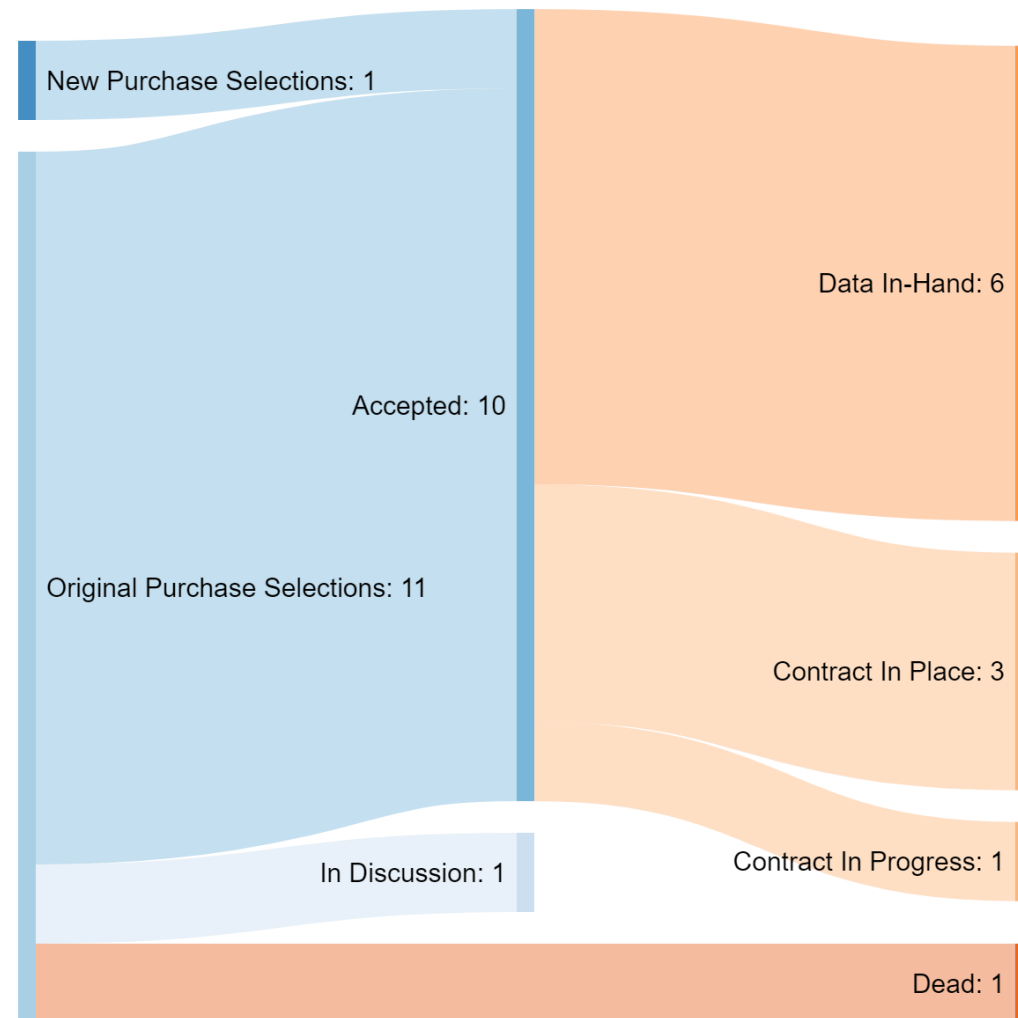- Done

Decide what data to pursue with funding
- Done

NDAs, subcontracts, etc.
- Finalizing

Commercial Submeter Data: Outreach Status (December 17)

Data Procurement (Purchase) Status

New Purchase Selections: 1
Accepted: 10
Original Purchase Selections: 11
In Discussion: 1
Data In-Hand: 6
Contract In Place: 3
Contract In Progress: 1
Dead: 1

Hurdles overcome:

- Uncertainty of original vendor estimates of dataset counts materializing into final contract counts

- Data provider difficulties allocating staff time for preparing and transferring data

- Data providers obtaining permission to share data

91% (10 of 11) of the original for-purchase data sources are being contracted for procurement

6 out of 10 sources have delivered data; 2 others targeting March; 2 others collecting data into summer

Oct 31 Package

- Contained 3 primary data source types:
  - **In-hand:** Data in project team's possession.
  - **Free/Public:** Data sets identified from old reports and other research outcomes that were not expected to require funding to obtain. All were pursued, some remain in discussion.
  - **For Purchase:** Data sets identified during the market outreach effort that would require funding and were selected for pursuit.

Free/Public Data Challenges

- Oct 31 package included several free data sets.
- Many came through or are still expected to, but there were challenges with several others:
  - Some useful data identified in old reports no longer exist.
  - Contacts that led certain studies are no longer with their organizations.

Sample Sizes: Weather-driven End Uses

Weather-driven	Proposed Minimum Sample Size[1]
Heating	48
Cooling	48
Fans	21
Pumps	21
Heat Rejection	21
Humidification	21
Heat Recovery	21
Refrigeration	21
Exterior Lighting	21

[1]*Minimum sample size targets presented at subject matter expert webinar on 8/28/2019.*

Sample Sizes: Weather-driven End Uses

Weather-driven	Proposed Minimum Sample Size[1]	Oct 31st Package Sample Size[2]
Heating	48	6218
Cooling	48	6598
Fans	21	2497
Pumps	21	500
Heat Rejection	21	21
Humidification	21	27
Heat Recovery	21	22
Refrigeration	21	1076
Exterior Lighting	21	846

[1]Minimum sample size targets presented at subject matter expert webinar on 8/28/2019.
[2]Counts based on vendor rough estimates obtained during market outreach

Sample Sizes: Weather-driven End Uses

Weather-driven	Proposed Minimum Sample Size[1]	Oct 31st Package Sample Size[2]	Procured Sample Size[3]
Heating	48	6218	**5176**
Cooling	48	6598	**5368**
Fans	21	2497	**328**
Pumps	21	500	**83**
Heat Rejection	21	21	**41**
Humidification	21	27	**22**
Heat Recovery	21	22	**36**
Refrigeration	21	1076	**1010**
Exterior Lighting	21	846	**846**

No gaps identified

[1]Minimum sample size targets presented at subject matter expert webinar on 8/28/2019.
[2]Counts based on vendor rough estimates obtained during market outreach
[3]Procured Sample Size includes data in hand and data that is being contracted for procurement

Sample Sizes: Schedule-driven End Uses

Schedule-driven		Hospital	Outpatient	Primary School	Secondary School	Full-Service Restaurant	Quick Service Restaurant	Retail	Strip Mall	Supermarket	Small Hotel	Large Hotel	Warehouse	Multifamily	Small Office	Medium Office	Large Office
Proposed Minimum Sample Size[1]	Interior Lighting	21	21	21	21	21	21	21	n/a	21
	Interior Equipment	21	21	21	21	21	21	21	n/a	21
	Service Water Heating	0	0	0	0	0	0	0	n/a	0
	Cooking	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[1]Minimum sample size targets presented at subject matter expert webinar on 8/28/2019.

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	Interior Equipment	21	21	21		21		21	21	21	21		21	n/a		21	
	Service Water Heating	0	0	0		0		0	0	0	0		0	n/a		0	
	Cooking	n/a	n/a	n/a		n/a		n/a	n/a	n/a	n/a		n/a	n/a		n/a	
Oct 31st Package Sample Size[2]	Interior Lighting	103	281	760		1046		137	53	270	20					337	
	Interior Equipment	2	285	196		214		4	5	25	22					270	
	Service Water Heating	0	0	316		106		0	0	0	0					1	
	Cooking	0	2	2618		0		0	1	0	0					0	

[1]Minimum sample size targets presented at subject matter expert webinar on 8/28/2019.
[2]Counts based on vendor rough estimates obtained during market outreach

=gap

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	Interior Equipment	21	21	21	21					21	21		21	n/a		21	
	Service Water Heating	0	0	0	0					0	0		0	n/a		0	
	Cooking	n/a	n/a	n/a	n/a					n/a	n/a		n/a	n/a		n/a	
Oct 31st Package Sample Size[2]	Interior Lighting	103	281	760	1046					137	53		270	20		337	
	Interior Equipment	2 (gap)	285	196	214					4 (gap)	5 (gap)		25	22		270	
	Service Water Heating	0	0	316	106					0	0		0	0		1	
	Cooking	0	2	2618	0					0	1		0	0		0	
Procured Sample Size[3]	**Interior Lighting**	**76**	**162**	**710**	**800**					**71**	**42**		**131**	**65**		**118**	
	Interior Equipment	**4 (gap)**	**594**	**202**	**196**					**3 (gap)**	**2 (gap)**		**52**	**367**		**91**	
	Service Water Heating	**0**	**0**	**317**	**107**					**1**	**0**		**15**	**98**		**1**	
	Cooking	**0**	**0**	**2620**	**1**					**1**	**0**		**0**	**0**		**0**	

[1]Minimum sample size targets presented at subject matter expert webinar on 8/28/2019.
[2]Counts based on vendor rough estimates obtained during market outreach
[3]Procured Sample Size includes data in hand and data that is being contracted for procurement

= gap

Significance of Remaining Gaps

National Commercial Building Electricity Consumption by Building Type and End Use (data from CBECS)
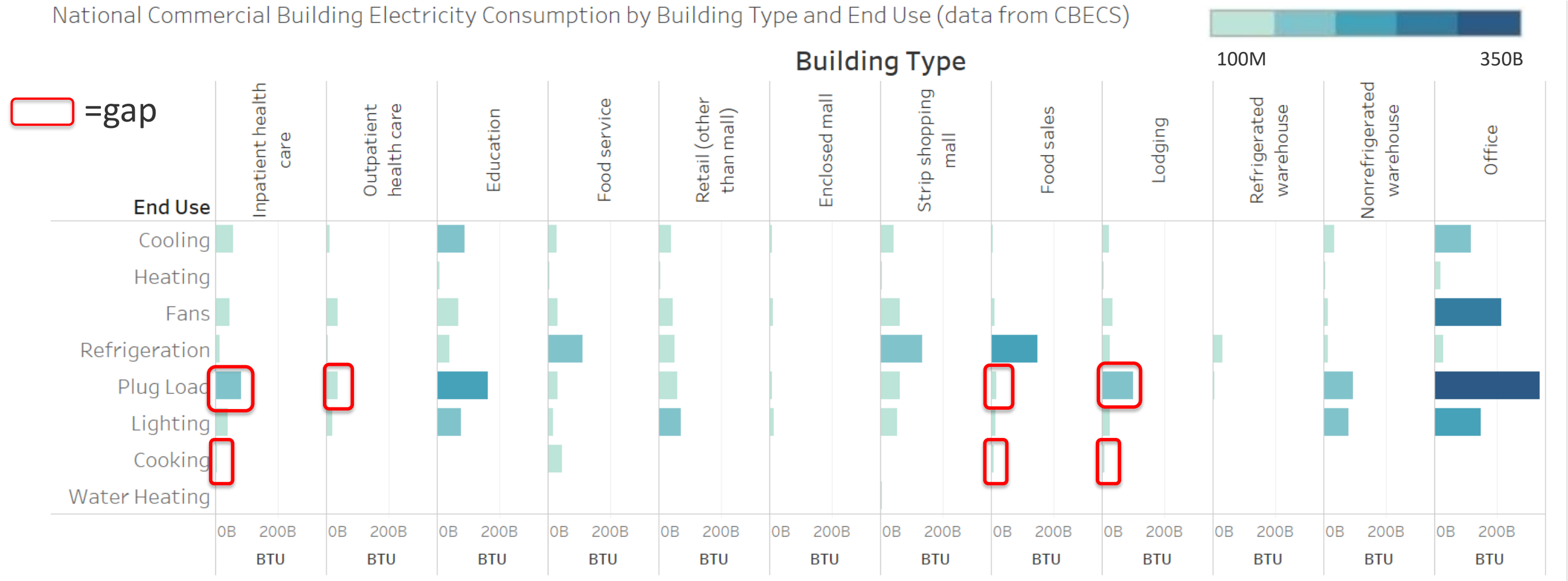
While the gaps are not all trivial, overall, CBECS indicates that they represent a small fraction of the total energy consumption in the stock.

Data Gap: Cooking

- Plenty of data under contract for food service cooking, but limited in other building types: education, food sales, lodging, and healthcare.

- **Options to fill gap:**
  - Time-series cooking data identified for an estimated 100+ buildings that covers key building types.
    - In discussion to obtain this data.
  - Determine transferability between building types as cooking loads may be largely similar.

- Will quantify resulting uncertainty in results.

Data Gap: Food Sales Plug Loads

- Limited grocery store plug load submetering data identified during market outreach.

- **Options to fill gap:**
  - Determine transferability of grocery store plug loads and other retail plug loads.
    - Cooking and refrigeration are calibrated using separate data – we expect the remaining plug loads to be similar to retail.
  - Extract from AMI and other available end use data.

- Will quantify resulting uncertainty in results.

Data Gap: Healthcare Plug Loads

- Limited hospital plug load submetering data identified during market outreach.
  - Sensitive application of the equipment
  - High metering costs
  - Strict healthcare security concerns
- **Options to fill gap:**
  - Contracting plug load metering from one hospital and possibly two more.
  - Hospital industry organization has provided promising connections that could yield hundreds of hospitals of BAS and AMI data (in conversation).
  - Back out plug loads using a combination of AMI, available hospital plug load data, and the other end use data that we have for hospitals.
- Will quantify resulting uncertainty in results.

Data Gaps: Lodging Plug Loads

- Limited lodging plug load submetering identified during market outreach.

- **Options to fill gap:**
  - Back out using a combination of AMI, available lodging plug load data, and other available end use data.

- Will quantify resulting uncertainty in results

Commercial Submeter Data: Geospatial Diversity

Schedule-Driven End Uses

Weather-Driven End Uses
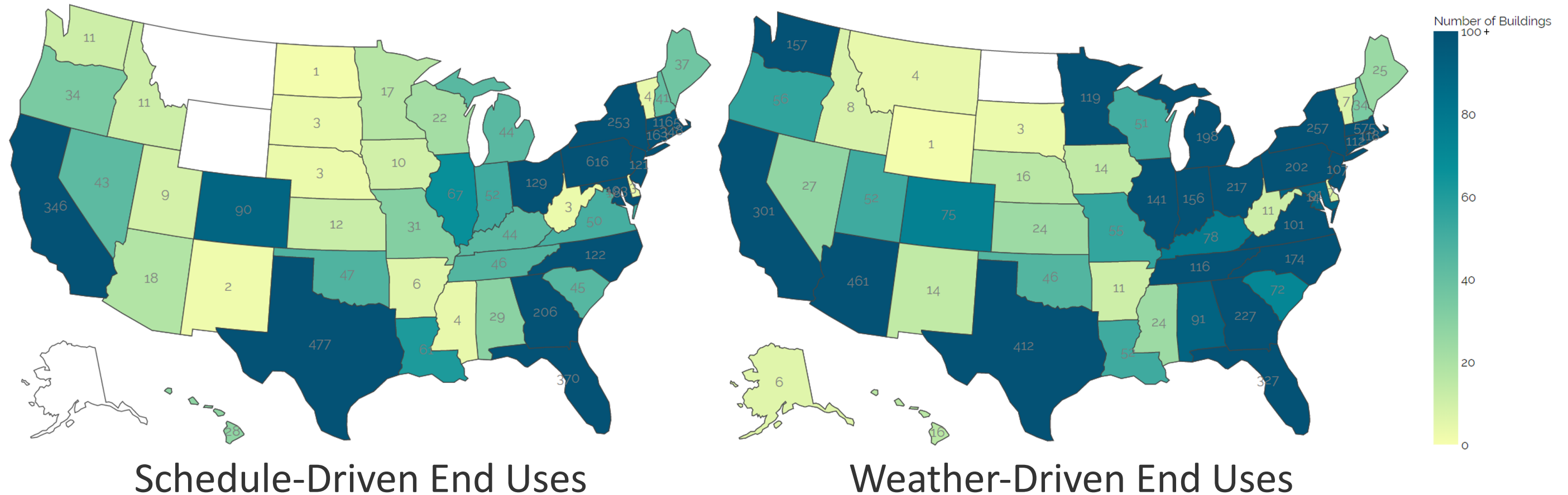
Good overall regional diversity, especially for the weather-driven end uses.

Data Procurement Status Summary

- Contracting 91% (10 of 11) of the originally intended purchased data source count.
  - 6 in-hand as of 3/19/2020
  - 2 more in contract expecting delivery in March
  - Remaining 2 are in contract collecting data and will deliver summer 2020
- Although a few data gaps exist, these are not major gaps in the overall energy use picture, and there are plans in place to address.

The procured data set is best-in-class with robust end-use, building type, and regional coverage. The project team is confident that this data set will allow creation of a national set of end-use load profiles that are _at least_ as accurate as other regional end-use load shape studies.

Update on residential end-use transferability study

Residential end use transferability

Question: Are residential end use patterns the same across regions?

- Navigant Massachusetts Residential Baseline Study **(Mass Res 1)**
  - **356 sites,** metered between May 2017 and April 2018
  - **Massachusetts**, representative sample
- NEEA Residential Building Stock Assessment: Metering Study **(RBSAM)**
  - **101 homes,** metered from 2012-04-01 to 2014-07-31
  - **Pacific Northwest**, representative sample
- Florida Solar Energy Center - Phased Deep Retrofit Study **(FSEC)**
  - **56 homes,** metered from 2012 to 2016
  - Central Florida, biased sample
- Pecan Street Dataport **(Pecan Street)** – Not shown (still awaiting approval to present)
  - **998 homes,** metered between 2011 to 2014
  - **Texas** (97%), biased sample
- American Time Use Survey **(ATUS)**
  - **~55,000** respondents from 2013–2017 (one day of activities per respondent)
  - National, representative sample

Residential end use transferability

Clothes Washer
Transferable across regions?

Old (bug in RBSAM processing)

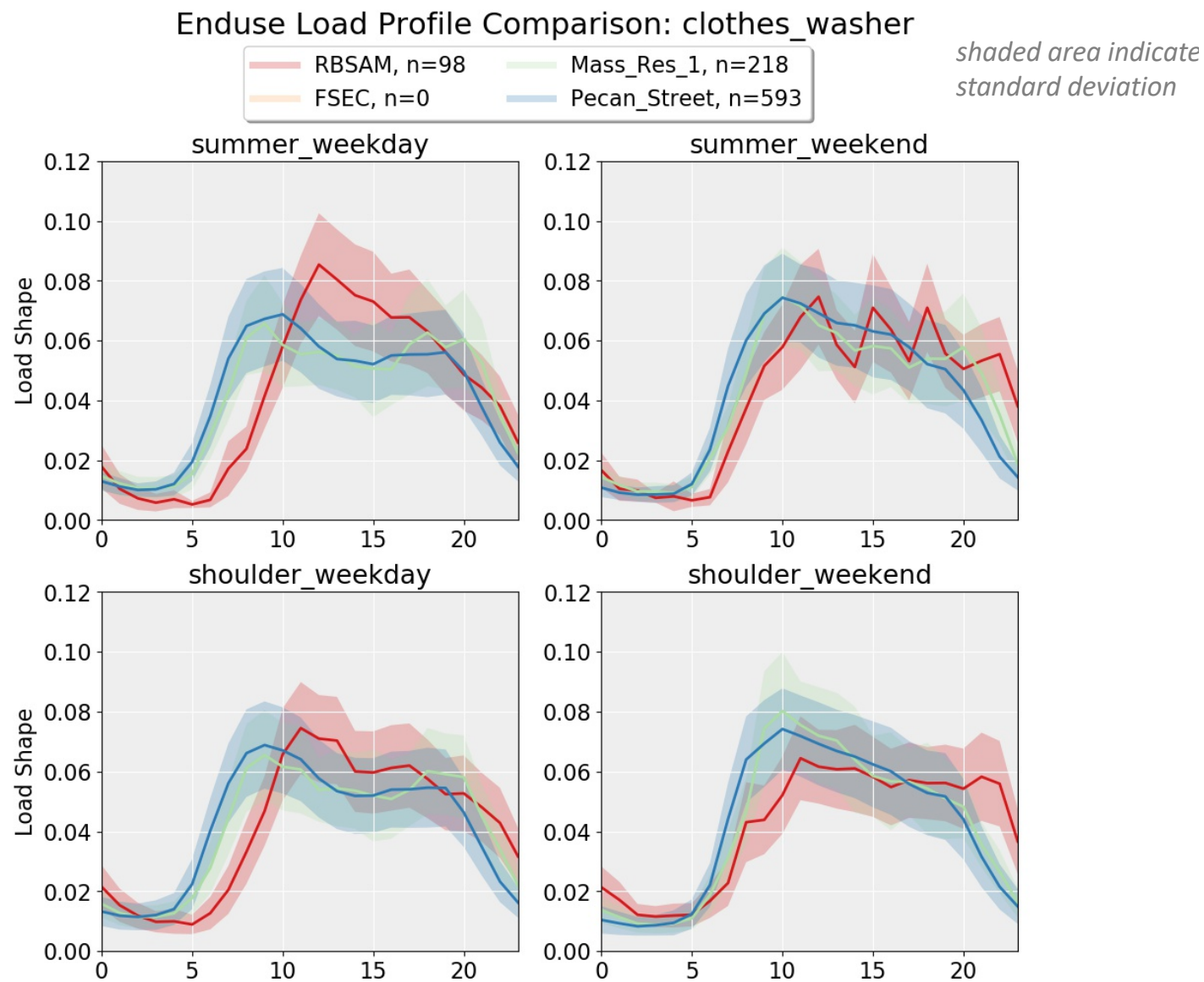Enduse Load Profile Comparison: clothes_washer
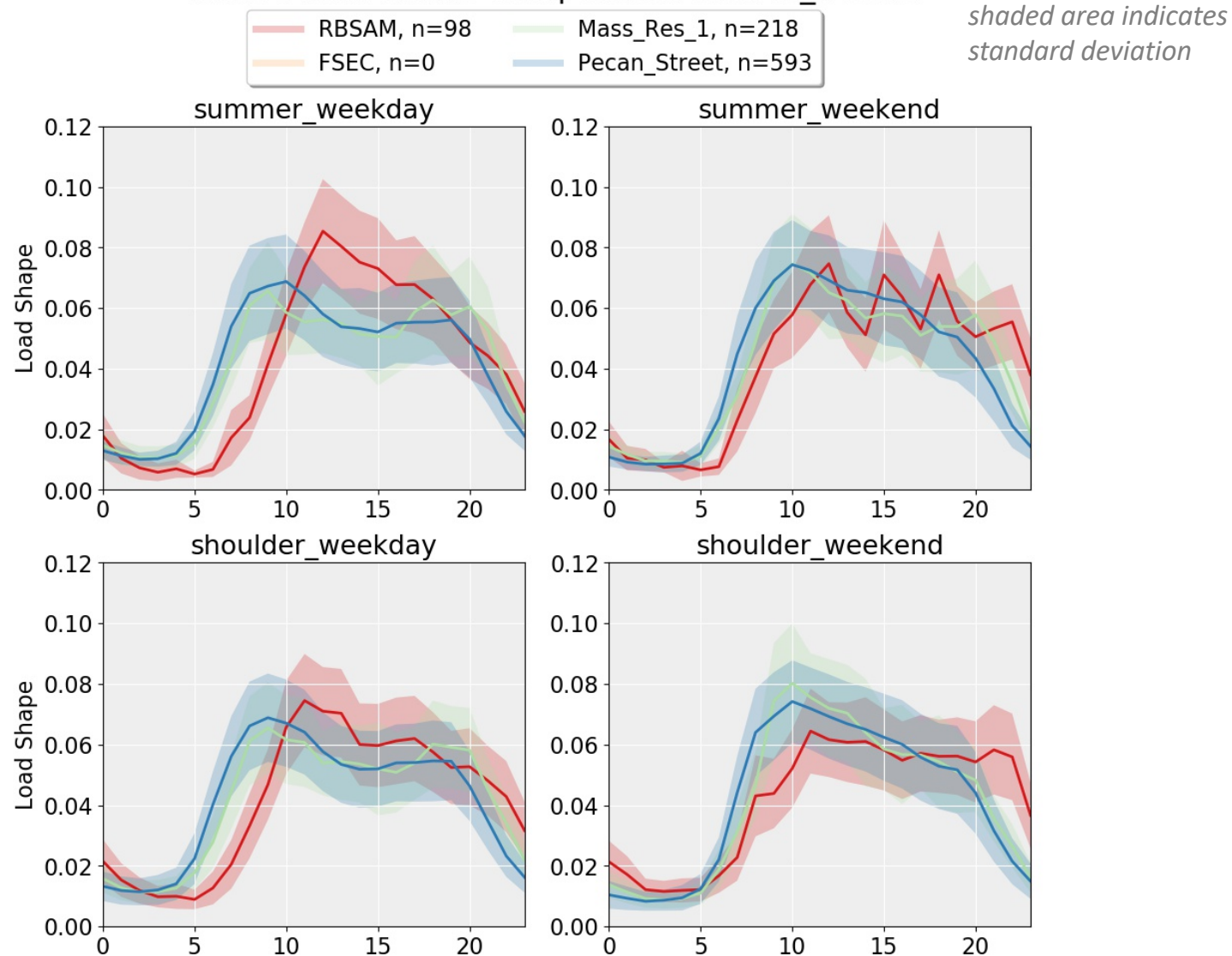
shaded area indicates standard deviation

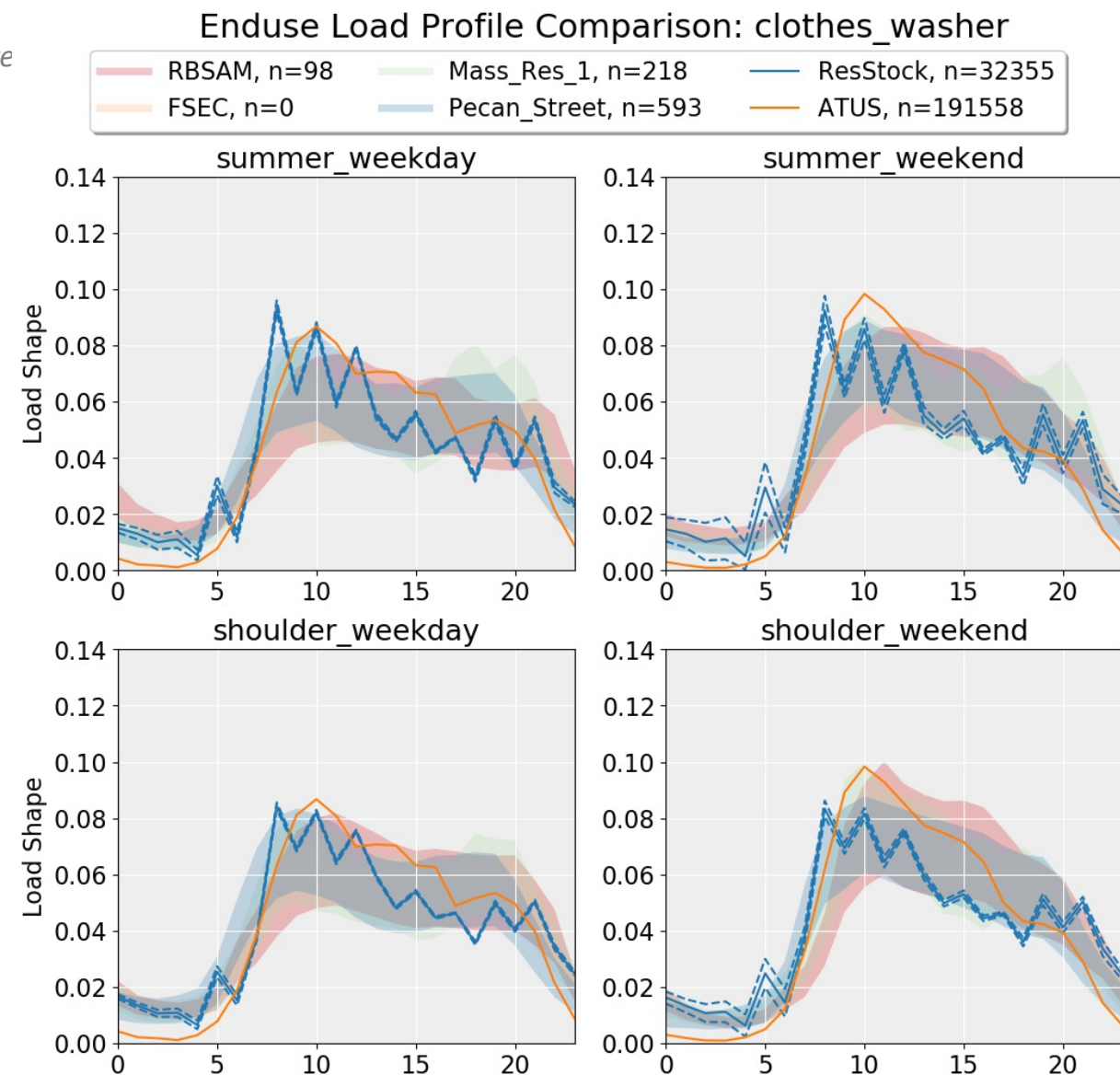# Residential end use transferability

Clothes Washer
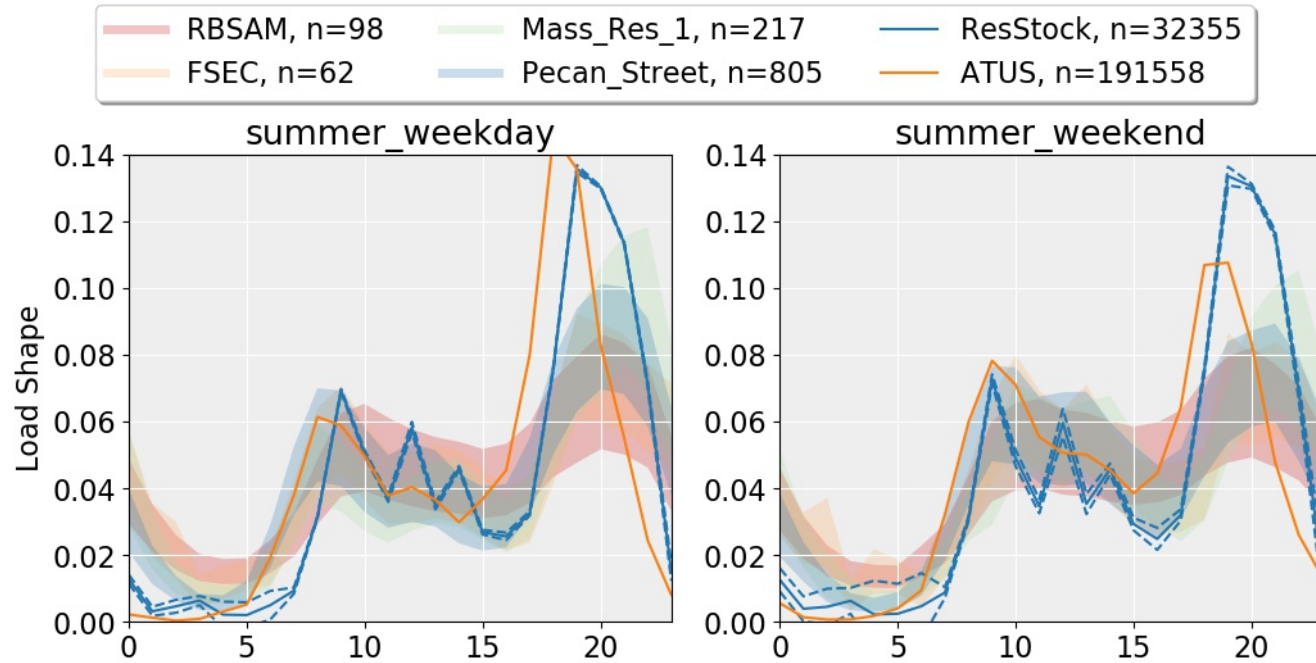Transferable across regions?
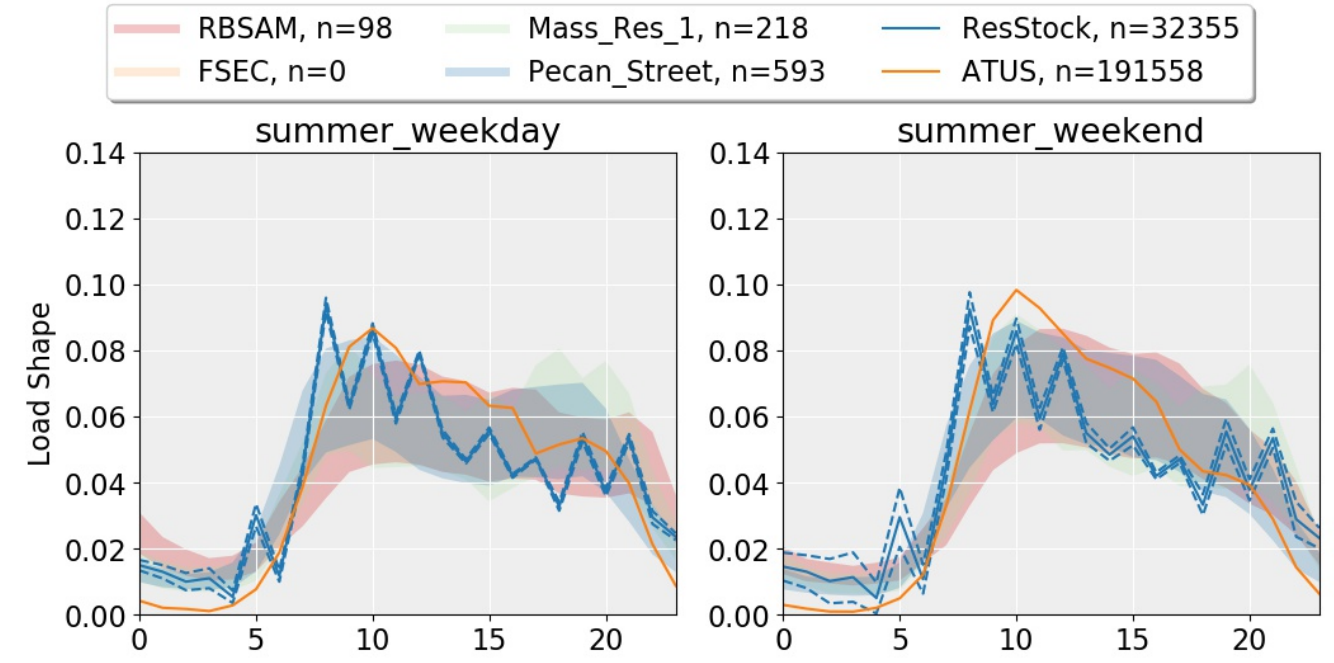
Old (bug in RBSAM processing)

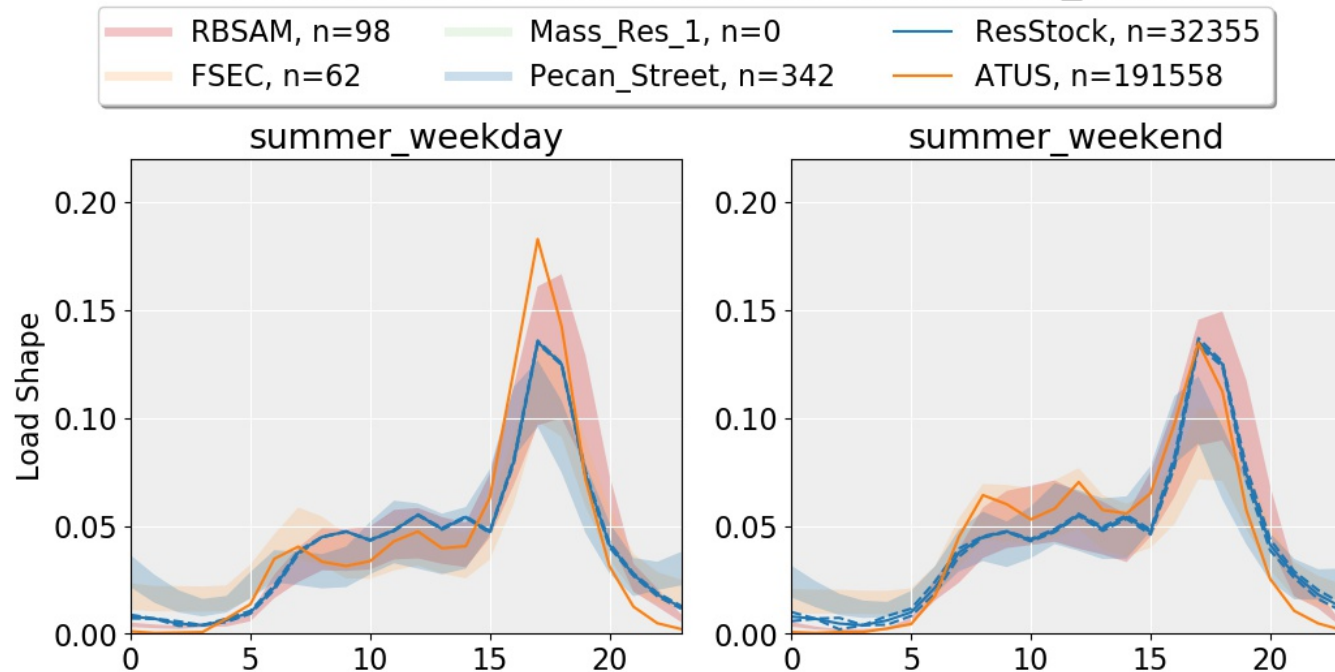New (bug fixed; added ATUS)

Comparing ATUS to end-use datasets
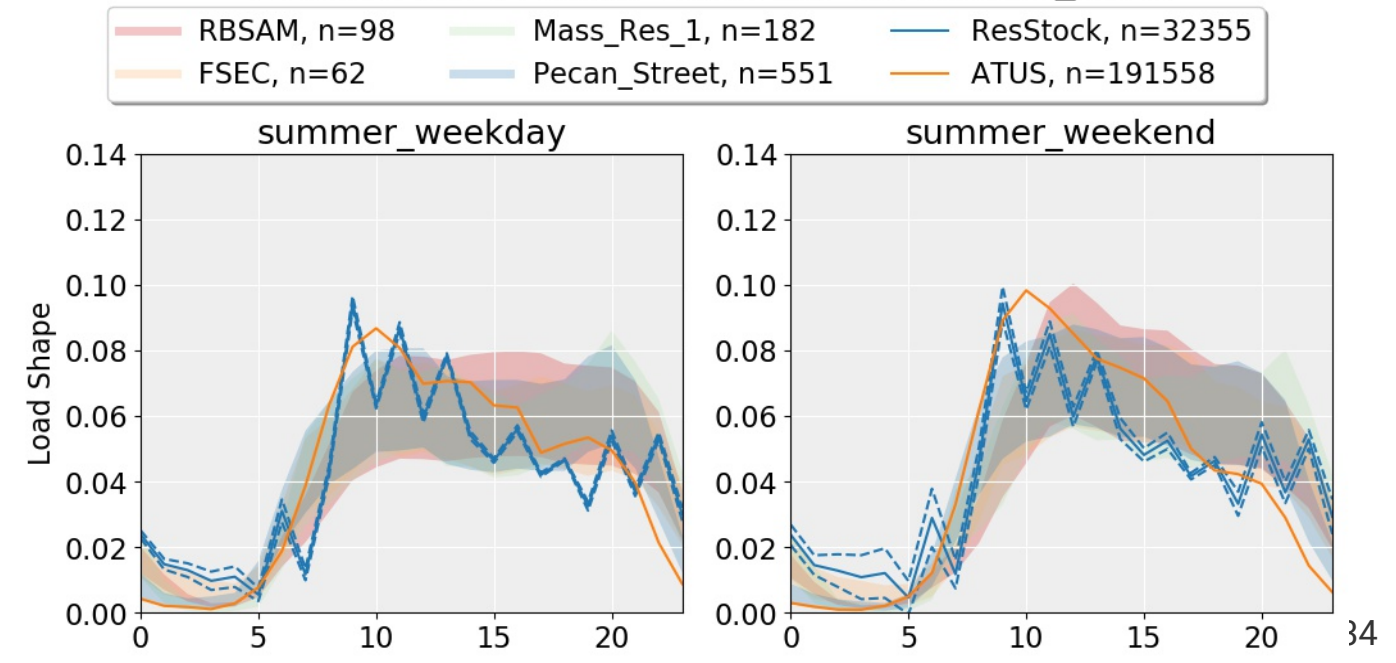

Enduse Load Profile Comparison: dishwasher
RBSAM, n=98 | Mass_Res_1, n=217 | ResStock, n=32355
FSEC, n=62 | Pecan_Street, n=805 | ATUS, n=191558

Enduse Load Profile Comparison: clothes_washer
RBSAM, n=98 | Mass_Res_1, n=218 | ResStock, n=32355
FSEC, n=0 | Pecan_Street, n=593 | ATUS, n=191558

Enduse Load Profile Comparison: cooking_range
RBSAM, n=98 | Mass_Res_1, n=0 | ResStock, n=32355
FSEC, n=62 | Pecan_Street, n=342 | ATUS, n=191558

Enduse Load Profile Comparison: clothes_dryer
RBSAM, n=98 | Mass_Res_1, n=182 | ResStock, n=32355
FSEC, n=62 | Pecan_Street, n=551 | ATUS, n=191558

Discussion

We are going to unmute all of the phone lines, so

please mute yourself if you are not speaking.

Next Steps

Next steps

- Continue procuring AMI data and commercial building end use data
- Continue residential and commercial occupancy modeling
- Complete framework for uncertainty quantification
- Complete residential sector calibration for the first region

Thank you

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www.nrel.gov

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NATIONAL RENEWABLE ENERGY LABORATORY

Discussion

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